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ABSTRACT

The goals of this research project included noting the importance that primary teachers placed on student ideas in planning and delivering science lessons for the topic of snails, and comparing the importance teachers afforded student ideas-and instruction based on student ideas-with the perception their students had of the importance of their ideas in class. To determine if teachers and students have the same perspectives on the importance of children's ideas, three primary classrooms in which teachers showed evidence of teaching science toward conceptual change were selected. The findings indicate that when elementary teachers are aware of student ideas and plan to address them in instruction, students may be more aware of their own ideas and the role they play in learning science. Recommendations for future research include focusing on conditions during which teacher recognition of student ideas influences teaching practice. Contains 51 references. (DDR)

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CHILDREN'S IDEAS IN SCIENCE: HOW DO STUDENT AND TEACHER PERSPECTIVES COINCIDE?

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CHILDREN'S IDEAS IN SCIENCE: HOW DO STUDENT AND TEACHER PERSPECTIVES COINCIDE?

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Introduction

Current reforms in science education focus on the need for students to conceptually understand science rather than knowing a breadth of science facts (AAAS, 1993; NRC, 1996). These recommendations are for all students, from kindergarten through high school and beyond. To understand science conceptually means to know the ideas of science and the relationships between them. It includes knowledge of ways to use the ideas to explain and predict other natural phenomena, and ways to apply them to other events (NRC, 1996). Developing understanding presupposes that students are actively engaged with the ideas of science. The reforms further suggest scientific understanding can be gained through inquiry instruction generated from student experiences.

According to Kelly's (1955) theory of personal constructs, thought processes are psychologically developed by experiences that serve to help persons anticipate future events. Prior experiences form background knowledge that is used to inform inferences to be made from future experiences. Thus, in any science classroom, it can be expected that children will have had experiences that helped them develop stable and functional constructs about the world. These constructs, or ideas, will influence interpretations made of explorations in science. Children's ideas are defined as experience-based explanations constructed by the learner to make a range of phenomena and objects intelligible (Wandersee, Mintzes, & Novak, 1994). Children's ideas are stable and resistant to change (Carey, 1985; Driver, Guesne, & Tiberghien; Novak, 1988; Stepans, Beiswinger, & Dyche, 1986). As long as the idea serves the learner in making sense of the world, it will remain the learner's theory (Driver, et al, 1985; Osborne & Freyburg, 1985). Children's ideas develop very early, and by the age of 5 or 6 children have evolved a robust and serviceable set of theories about their world (Carey 1985; Gardner, 1991; Piaget, 1929). Regardless of the recognized influence of student ideas, the reforms have recommended conceptual understanding of science. Recognition of children's ideas by teachers is imperative in helping students develop conceptual understanding of science content. Teachers can use their knowledge of student ideas to help scaffold them to more accurate levels of understanding.

Posner, Strike, Hewson, and Gertzog (1982) theorize that students will remain committed to their ideas unless they are shown the necessity of modification. The student must be dissatisfied with the existing conception, meaning the child's idea must no longer make sense to the child in explaining the concept. A new idea must be intelligible as well as plausible. Finally, the conception must be fruitful, and make sense in many situations. Strike and Posner (1992) reiterated that their theory of conceptual change is not a prescription for instruction, but only conditions necessary for ideas to change. A way for teachers to help students change ideas would be to scaffold them to a more accurate level of understanding (Rogoff, 1990; Vygotsky, 1991). Scaffolding children's thinking in

curricular areas is a strength of primary teachers (Cazden, 1988). Primary children are not inhibited from sharing ideas, nor are they willing to keep them quiet. They are active, and willing to describe what they are doing and thinking. Primary teachers who are attentive to these students are fortunate in being able to elicit ideas with little prompting. Primary teachers are also fortunate in the students' willingness to manipulate equipment and discuss what they are learning. Teacher input in the discussion will help scaffold students to new understandings (Gallas, 1995).

Most primary teachers are not science specialists. Primary children do not recognize the difference between scientific and general ideas about the world. To these young students they are simply learning about their world. Science is only one of numerous subjects an elementary teacher must teach. Arguably, the most important task for an elementary teacher is to teach students to be literate readers and writers in the context of an integrated, or at least conceptually holistic curriculum. Primary teachers necessarily have an expertise in language arts, and can use this expertise to help scaffold student learning in science. Science, as a separate subject, in the primary grades is given a smaller amount of instructional time in comparison to other subjects. Stefanich (1992) found that in 50% of the primary classrooms activity-based science comprised a maximum of 20% of the instructional time. In the remainder of the primary classrooms all of the science instructional time was composed of textbook readings. Science does not comprise a large portion of classroom time in elementary schools, and when science is taught in the primary grades it is often through use of textbooks. Having primary children follow along in a textbook as a passage is read surely is not teaching science conceptually.

In addition to limited time spent on science, there are other factors that influence teaching elementary science. These factors are: (a) teacher perception of the importance of science in an elementary curriculum, (b) limited content knowledge held by elementary teachers, and (c) limited experience through formal coursework in participating in and presenting, hands-on science. Elementary teachers do not often see science as a important topic, but rather as something to be taught only when other subjects have been covered (Abell & Roth, 1992; Schoeneberger & Russell, 1986; Tilgner, 1990; Tobin, Briscoe & Holman, 1990). Administrators do not always see science as an important subject in elementary schools (Schoeneberger & Russell, 1986; Tilgner 1990). Seeing science as of little importance leads to less funding and support of elementary science (Stefanich, 1992). Because of lower funding, elementary teachers are likely to have inadequate equipment for teaching science. Inadequate equipment and limited time often inhibit teachers from providing in-depth instruction (Stefanich, 1992; Tilgner, 1990).

Elementary teachers lack confidence in their abilities to teach science because of weak content knowledge (Borko, 1993; Enochs & Riggs, 1990; Smith & Neale, 1989). Even elementary science enthusiasts who effectively teach concepts for which they have good background knowledge, have difficulty teaching other science concepts because of inadequate content knowledge (Abell & Roth, 1992). Lack of confidence and content knowledge is not unique to science, but is also present in other curricular areas, such as social studies.

Elementary teachers often have not had experience participating in hands-on science, and therefore are unsure of how it should proceed in their own classrooms (Bybee, 1993). Typically, elementary teachers take introductory science courses in their

teacher preparation programs, yet those courses often do not suit their needs or interests (Tobias, 1992). Elementary teachers with a positive attitude and interest in learning science may find college science coursework inhibiting to their learning (Dickinson & Flick, 1996).

Even with these barriers to teaching science, many elementary teachers provide effective instruction. Research evidence suggests this is accomplished by the elementary teachers using other areas of strength to help them provide instruction that allows students to share ideas and conceptualize what they are learning in science (Flick, 1995). The ability to orchestrate discussions that elicit children's ideas and help students build on and change them, is an important component of effective science instruction. Elementary teachers with expertise in conducting such discussions may have an advantage in identification of, and accounting for, children's ideas.

Statement of the Problem

Given the recommendations of national reforms for students to develop a conceptual understanding of science (AAAS, 1993; NRC, 1996), a logical starting point would be to study teachers' conceptions of science. Evidence indicates elementary teachers have low science content knowledge (Kruger, Palacio, & Summers, 1992; Kruger, & Summers, 1989; Lawrenz, 1986; Smith, & Neale, 1989, Stoddart, Connell, Stofflett, & Peck, 1993). Too often the problem is cast in terms of teacher deficiencies which has led to a recommendation to improve science knowledge without an improvement of the understanding of the relationship of science to an elementary curriculum and how it should be taught (Flick, 1995, 1996). If we are to begin to help students meet the standards, there is a bigger problem to be studied, and that is how teachers will attempt to help students develop conceptual understanding of science. Knowledge of student conceptions has been shown to be a key to helping students develop more accurate understandings of science. The ideas children bring to the science classroom have an impact on what students gain from instruction as they are generating meanings from their experiences and discussions. Children's ideas interact with those presented by the teacher. In the absence of a teacher who understands and uses knowledge of children's ideas to inform instruction, children are unlikely to develop their ideas toward the scientific convention (Driver, Guesne, & Tiberghien, 1985). It is important to note how teachers use student ideas in planning and delivery of instruction, and whether this effort affects student learning. A first step is to note student perceptions of the importance of their own ideas in the science classroom.

Purpose

A focus of this project was to note the importance primary teachers placed on student ideas in planning and delivering science lessons for the topic "snails." Another purpose was to compare the importance teachers afforded student ideas, and instruction based on student ideas, with the perception their students had surrounding the importance of their ideas in class. Do teachers and students have the same perspectives of the importance of children's ideas?

Theoretical Framework

Because children's ideas exert such an influence on the effectiveness of classroom instruction, there have been recommendations to help students move toward a scientific viewpoint (Gilbert, Osborne, & Fensham, 1982). Students need to be aware of their own views, as well as the scientific view. To help students see the usefulness of the scientific viewpoint, teachers need to be aware of children's ideas and elicit their own students' views to plan activities and discussions to help narrow the gap between children's ideas and the scientific viewpoint. Indeed, how could a teacher possibly help students be aware of their views, if the teacher is not aware of those ideas? In the absence of knowing children's ideas teachers can be teaching directly past students without even realizing it (Erlwanger, 1975). The student may be able to provide the expected response, yet maintain an understanding inconsistent from that of the teacher or the scientist. If the teacher is aware of the views children bring with them to science classrooms the teacher may adjust instruction to take these ideas into account.

Piaget (1929) pioneered the study of young children's ideas about the world with the development and use of the clinical interview method. Science educators have adapted the clinical interview method to explore children's ideas in a plethora of science content areas (Osborne & Freyburg, 1985; Posner & Gertzog, 1982; Thier, 1967). Results of the study of children's ideas show that school children can proceed through their school careers and retain misconceptions about many science concepts (Anderson & Smith, 1986; Bar, 1989; Bishop & Anderson, 1990; Griminelli Tomasini, Gandolfi, & Pecordi Balandi, 1990; Hashweh, 1988; Hesse & Anderson, 1992; Nussbaum & Novak, 1976). The kinds of science instruction children are receiving do not seem to be effective in helping students change their conceptions toward the scientific convention. Students may be presented with evidence that their ideas are incongruent with an experiment or problem and reject the evidence, or reinterpret it differently within their own beliefs (Osborne & Freyburg, 1985). Even when students present what appear to be correct responses, they continue to harbor their own ideas (Driver, et al, 1985; Erlwanger, 1975; Herscovics, 1989; Osborne & Freyburg, 1985). Previous research on children's ideas has focused on describing them, providing knowledge of many misconceptions that are likely to be found in students of different ages in different subject areas (Bar, 1989; Hashweh, 1988; Nussbaum & Novak, 1976; Piaget, 1929). In addition, methods based on student conceptions, such as the learning cycle (Smith,1983), analogy (Stavy, 1991), or written and oral language (Fellows, 1994), have been used by researchers to help teachers change these misconceptions in their students. However, in the studies it was not clear whether the classroom teachers were aware of their own students' ideas, nor even if they were aware of typical misconceptions held by students in their grades. Students in such classrooms continued to hold on to their erroneous ideas, and the teacher was unlikely to realize their students held such ideas. Additionally, classroom observations were not always conducted, or were sporadically conducted, that limited information about how teachers actually implemented the procedures. Some methods researchers used for identifying student ideas, such as clinical interviews, would not be feasible for teachers to use in every day practice.

Teacher knowledge of student ideas is an important component of pedagogical content knowledge. Pedagogical content knowledge refers to the ways teachers transform

content knowledge to a form students can interpret (Shulman, 1986, 1987). A key aspect of pedagogical content knowledge is a teacher's knowledge of the ideas children already have about the subject. The teacher can then choose representations, examples, experiences, or hold discussions that would be suitable to help students deepen their understandings. While pedagogical content knowledge appears to focus on facility with teaching strategies, it is dependent on the content itself. Pedagogical choices depend on the content to be delivered. Knowledge of the ideas children bring with them to the science classroom can be extremely useful in deciding how to represent science content for instruction (Geddis, Onslow, Beynon, & Oeschk, 1993). Knowing students' ideas is part of the pedagogical content knowledge of elementary teaching, and can allow the teacher to provide experiences to help students understand the content.

Design and Procedures

Description of the project

The current study was set in the context of a larger project. The classrooms were part of an NSF-funded project "Integrating Science Concepts (ISC)." The purpose of the project is to help elementary teachers build content and pedagogical knowledge for teaching science. A major component in the project was to help teachers recognize student ideas when teaching science. The teachers attended monthly workshops and two three-day retreats taught by university science educators to help them improve their science teaching. In addition, teachers were required to video tape their science teaching. They were required to observe other teachers, and have peers observe their science teaching. They maintained journals of their teaching, and the content they were learning in the workshops. Teachers made notes in their journals based on journal prompts from the workshops, and from ideas they had during their teaching.

Selection of subjects

Three primary classrooms were selected to provide in-depth information on the learning outcomes of the students of the teachers in the project. Teacher selection was based on criteria derived from observations of teachers during ISC workshops, from lesson plans and journals required by the project, and from video tapes of classroom teaching.

Teachers were selected who demonstrated a range of abilities across the different criteria. In the first criterion teachers showed evidence of the use of teaching ideas presented in workshops through their videotaped lessons by (1) selecting topics similar to those presented in workshops, (2) focusing on student ideas, (3) attempting to teach scientific concepts, and (4) attempting to integrate elements of the nature of science.

In the second criterion, teachers showed evidence of teaching science toward conceptual change by responses in their journals indicating (1) a view of science as more than something simply to do as a fun activity, (2) a view of science as more than a way to give information to their students, and (3) a view of science as an important part of the curriculum, and something students need to understand.

For the third criterion, teachers showed evidence of understanding, or developing an understanding of science content through responses to questions in their journals by (1) showing reflection on the meanings of the scientific content they were learning, and (2) receiving replies to their journal entries by project staff indicating teachers were progressing in learning accurate science content.

In the fourth criterion, teachers showed evidence of applying what they have learned to their teaching through their lesson and unit plans by (1) developing their own lessons or adapting lessons from source books for their students rather than using lessons straight from a textbook, (2) including elements of the nature of science, (3) including clear objectives for science content, and (4) including clear plans for assessment and evaluation of science content and nature of science elements. Another consideration for selection was that teachers were regular classroom teachers whose assignments were of a single grade level.

These criteria were applied to documents available during February 1996. These data were triangulated with results from the Constructivist Learning Environment Survey (CLES) (Taylor, Fraser, & White, 1994) collected in July 1995. Interestingly, the criterion for selection did not triangulate well with responses to the CLES instrument. To illustrate, three primary teachers were selected, two of whom were identified as high ability in developing and maintaining a constructivist learning environment, based on project criteria described above. One was a kindergarten teacher, Ms. Green, the other a third grade teacher, Ms. Duncan. On the CLES instrument, Ms. Green was identified as a low constructivist teacher, while Ms. Duncan was a medium constructivist teacher. Mr. Hinckley, a second grade teacher, was identified as a low constructivist teacher by selection criteria, but a medium constructivist teacher by the CLES instrument. Possibly the time difference (July 1995 to February 1996) made an impact on teacher ability. Another possibility for the discrepancy is direct observation of the teacher's implementation of practice was more telling than the self-reporting they did through the CLES. The results of the project selection criteria were used in identifying the kindergarten and third grade teachers as high, and the second grade teacher as medium, in their efforts to develop a constructivist environment.

Data Collection

Each teacher was observed at least twice during the course of the school year by the researchers. Each teacher provided a "baseline" video tape to the researchers. This video tape contained a science lesson presented prior to the teachers' involvement with the ISC project. During their involvement with the ISC project, the teachers were required to design a unit incorporating the ideas of the project. They were required to teach a science content subject that had been presented during the workshops, incorporating nature of science elements, and which focused on student ideas. Toward the conclusion of their involvement in the project, the teachers provided the researchers with a three-lesson video tape containing science instruction during the course of the teacher-designed unit on snails. The researchers watched and made notes of the content of each teaching segment. Teachers participated in post-instruction interviews surrounding their goals for teaching science, the importance they place on student ideas when teaching science, and how they

teach science. Following instruction at least six students were interviewed from each classroom, to gain insights of their content knowledge of snails, perceptions of the nature of science components, perspectives on teacher practice, and perspectives on their own ideas in science. Teachers helped to select the students to represent a range of high, medium, and low-achievement in science. Students interviewed also represented a balance of genders. Each of the 30 minute interviews was audiotaped and later transcribed. A listing of the interview questions appears in the appendix.

Data Analysis

Data analysis was a process of combining data from the various sources to a coherent whole. The researchers listened to audiotaped interviews, read interview transcripts, looked at lesson plans, watched the video tapes of lessons taught during the unit, and viewed student work. During the review of all data, patterns were searched for indicating a focus on student ideas by the teacher. Also sought were perceptions of teaching by the students, and the importance of their own ideas in the classroom. The researchers made notes of the videotaped teaching episodes, while drawing inferences of the teacher's intent for certain activities, discussions, and assessments. These videotape viewings were compared to notes taken during classroom observation. The videotaped teaching episodes and classroom observations were used as a primary data source. These data were triangulated with teacher and student interviews, and lesson plans and student work.

In addition, teacher and student interviews were included to provide a picture of the importance of student ideas in the classroom, and how and if those ideas were made known to the teacher and the students. Interview responses were used to note whether what teachers stated in interviews concerning the importance of children's ideas was evident in their lessons.

Lesson plans were collected to gain insight on the teachers' focus for science learning. A comparison of what was planned to be taught was made with what was actually presented in the classroom. The comparison allowed the researcher to note any discrepancies with planned identification of student ideas to actual classroom practice. Student work was also collected to provide insight into what teachers would require of students that may be based on their ideas, and the types of responses students would feel were appropriate to make to teacher queries.

Findings

Teacher perceptions of student ideas

Each teacher purported to be influenced by student ideas when planning and carrying out instruction. Through interviews and observations it was evident the teachers did, indeed, plan activities in advance to help them understand students' conceptions. For instance, at the beginning of the snail unit, each teacher required students to make drawings of how they thought snails actually looked. Students were asked to make the drawings look as real as possible. It was questionable how the teachers used the

information gathered during this activity to plan future lessons. The teachers did focus on student ideas, but how these ideas were used in planning was not always clear. Each teacher is discussed individually below.

Ms. Green

The kindergarten teacher stated she planned her lessons and adapted her teaching based on her students and what she found they already knew. She stated she focused on science in the following manner:

> I start the kids with a basic question. Whatever the question of the day is. And then have discussion, do some brain storming, trying to establish a mind set, and then give them materials to explore with that I hope will help them begin getting some information that they understand. And once we've done exploration, then I can make my observations. What are they getting, some questions and strategies. Then I like to bring them back together, point out some observations, and then send them back with that new information--in that manner. Bring them back, send them out, bring them back. And then once we're finished, whichever way the lesson goes, then we come together and we'll either, often we talked about that there will be some recording. Whether, with kindergartens they don't write a whole lot, but they do draw a picture well. So we'll talk about trying to consolidate our information, so I can see what they're still hanging on to what information, and then do some evaluation with them, then we're done.

Ms. Green indeed started her snail unit with a "question of the day." She prompted her students' thinking about snails by directing them "In your snail book—draw a picture of what you think a snail looks like. Make it look as real as possible." Students were given approximately 15 minutes to draw their snails in a stapled booklet of blank pages called the "snail book." Ms. Green then passed out live snails to each student, and gave them magnifying glasses, and asked students to observe the snails for about 15 minutes. During their observations, Ms. Green walked around the room, helping students with the magnifying lenses, and checking observations they were making. She then collected the snails and had students make another drawing with the prompt "Draw a picture of the snail you just looked at." Students were again given about 15 minutes to make their drawings. Students were asked to convene on a carpet at the front of the classroom, bringing their snail books with them. Ms. Green asked students to share some observations they had made about the snail. Students replied that snails were soft, slimy, icky, and had long eyes. Ms. Green asked for volunteers to share their books so she could point out differences between the snail drawings. She did not have the students point out differences in their ideas for their peers, but did it herself. By not having students point out the differences between their before and after drawings, it seems she was not allowing them to share their own ideas. However, in a later conversation with the researcher, the teacher very enthusiastically discussed the differences between the drawings of the snails. She believed students gained more accurate perceptions about snails from their

interactions, and thought the drawings provided evidence of their growth. Figure 1 shows an example of a student's before and after snail viewing drawing.

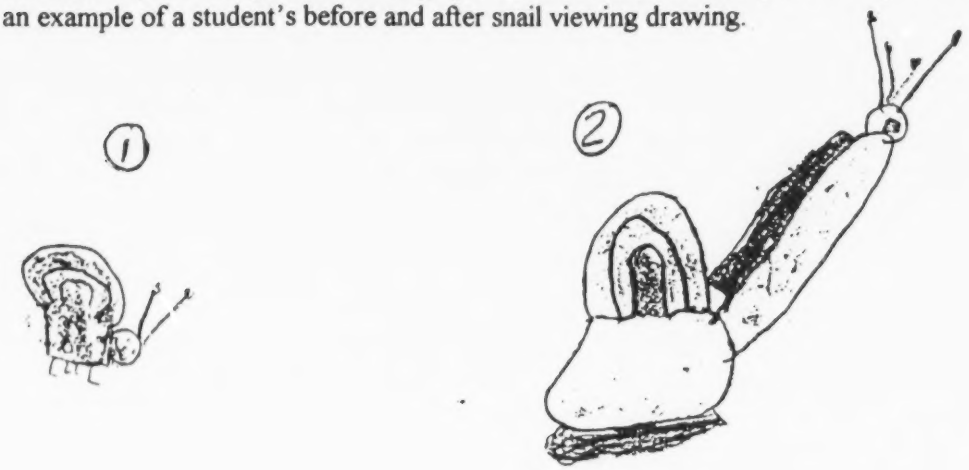

Figure 1. Example of Kindergarten pre- and post-instruction snail drawing.

The second lesson also began with a sharing of student ideas. The teacher asked, "Is the whorl the same on both sides of the snail?" and "Is the foot the same on both sides?" The teacher had the students vote on whether or not the foot and whorl were the same on both sides of the snail. Students were then given approximately 20 minutes to observe their snails and make drawings in their snail books. As the children were making observations the teacher circulated the room to watch the students. She spent much time clarifying the second question. She meant for students to note whether the foot was different from top and bottom, but the students interpreted it as from side to side. She clarified this question by explaining what she meant to small work groups.

During the subsequent class discussion students were asked to provide examples of differences they noted about the shells and the feet. The prompts were very open-ended, allowing students to respond with their own findings. For instance, the teacher asked "How do snail shells differ on each side?" Students responded "it is larger on one side," "it sticks out on one side but not the other," and finally, "one side has a swirl and the other doesn't." Again, students were allowed to present their own ideas, yet they were not asked to infer reasons for differences, just focused on noticing differences were present.

The third lesson had students involved in an investigation of what kinds of things a snail would like to crawl on. It was begun with a "question of the day" teacher prompt of "Will a snail crawl on a marker, yarn, or a straw?" Students were asked to repeat the question so the teacher knew they understood the problem. They were then asked to predict what snails might like to crawl on, and to draw their findings in their snail books when they were done with their investigations.

Following the investigation the children were again convened in a large group for discussion of the results. The children concluded that snails liked to crawl on "smooth things" since the snails seemed to crawl the most on the markers. Students were not asked to infer why snails would most like to crawl on smooth things.

Ms. Green was open to identifying student ideas, and planned activities to allow student input in the science classroom. She allowed students to share their own ideas about snails through drawings and discussions, and the drawings were made in snail booklets which were actually blank pages stapled together. Children were allowed to fill the pages with recordings they made from their thoughts and their investigations. Yet children's ideas were not always a focus in the classroom. For instance, when students made the subsequent snail drawing after observing the snails, students were not the ones identifying the differences between the drawings, rather, the teacher was the one drawing the conclusion. Furthermore, students were not questioned for their ideas of why there would be such differences between the drawings. Their attention was not drawn to the advantage of actually observing the snails when making the drawings versus trying to draw the snail based on memory. It could be stated that Ms. Green was not basing her teaching on student ideas, yet in some instances she was concerned with their thinking. Ms. Green was also very concerned that students not leave her classroom with erroneous ideas, and that she was presenting them with material that was appropriate for their age. The statements below illustrate her concern:

> Science, in some respects, scares me because you have to be so careful about the ideas you plant in kids' heads when you present information. Like, for me to think about getting up in front of the kindergarten class and showing them that they can take a cord and separate it and stick one end into a pickle and stick the other end into an electrical current. There has to be some professional responsibility with the topics and the examples you use when you work with children. Any age of children. Five years (old) especially.
>
> I know you can't ever cover all of your bases, but you really have to think about what is appropriate for that age. It may be a cool experiment, but is it appropriate? What are you trying to accomplish? What does it really tell about the concept? Did it engage them? And if that's what you want to do is engage them, there's one way to do it, but there are other ways to do it. I worry, those little kids in the classroom doing science but when they go away and those little minds start churning through all the activities, what are they really getting?

It is possible Ms. Green focused on student ideas to the point she believed her students could manage them. She did not want students to come away from her classroom with erroneous ideas, so she chose to focus the students on ideas she believed were more correct by drawing the conclusions for students. For instance, when she had students share their snail drawings and pointed out the differences between the 'before' and 'after' drawings, it is possible she wanted them to notice certain differences she was not sure they would notice on their own. She may not have thought it would be age appropriate for her students to draw inferences, but that it was perfectly appropriate for them to make observations, as was her focus for the students throughout the snail unit—for them to make observations.

Mr. Hinckley

According to Mr. Hinckley, the second grade teacher, children's ideas were a major focus in his teaching. He wanted students to give their own theories, and claimed to base his lessons on what students said in class discussions. For example:

> I try to get the kids to come up with theories about why they think something is happening. The best lesson is to have them deal with the question, develop a theory as to the solution of the question and then try to test that. That doesn't always happen in one lesson. They'll suggest, they'll say "well, how come," I'll say "well, that's a good question, what could we do to figure that out?" And they'll say "you can try this," And I'll say "lets do it." And that's the kind of thing that's really powerful. They love that kind of stuff. When the teacher says, "Oh, why don't we figure that out..." It gives them control of their learning. That doesn't happen a lot at school.

Like Ms. Green, Mr. Hinckley wanted to uncover student prior knowledge about snails. He began his snail unit by asking students to tell him everything they knew about snails. He listed student responses on the blackboard. All responses were accepted, and he probed for additional information should a student's response seem to require it. For instance, in the interchange below, his inquiry required the student to rethink the statement made, while not giving the student a specific answer.

> S_1: Snails can leave their shells. Then they will find another shell.
>
> S_2: Snails can't leave their shells! The shells are attached! (There was much discussion and disagreement among the students.)
>
> T: We will find out much more about snails. By watching maybe we will find out whether they leave their shells.

Students were then asked to draw snails as they believed snails really look. From the teaching segment viewed, it seemed they did not share their drawings with other students. While the students were drawing, Mr. Hinckley sat on a chair at the front of the room, looking at other papers. It was clear he was not attending to what the students were doing at that moment, other than to state an occasional reminder to do their best drawing, and to use shading on their snail drawings.

The second lesson observed followed lessons during which the students were allowed to explore the snails in a hands-on fashion. Mr. Hinckley built on their explorations by beginning the day's inquiry by holding a discussion surrounding why students believed snails had brown markings on their shells, and why their shell was shaped in a whorl on one side. Students were not certain how to respond, and Mr. Hinckley asked, "If a shell is to protect a snail, what would happen if it had a different

shape, such as a long shape?" Students responded, "It would be harder for the snail to hide." Mr. Hinckley was satisfied, and then asked students to compare their fingerprints to the snail's shell whorl. It was unclear of his purpose when he asked students "What is the relationship of a snail whorl and a human's fingerprint whorl?" Students did have responses, stating that fingerprints were sometimes in whorls, but did not provide responses indicating a relationship. It is not likely there actually is a relationship between the whorls of a human fingerprint and a snail's shell, which is why it was difficult for students to respond. Students were then given snails at their desks and asked to draw the snail's whorl and compare it to their own fingerprint.

At the conclusion of the discussion, children were asked to think again about why snails have different markings on their shells. Students provided two responses: (1) so the snails can tell each other apart, and (2) for camouflage protection. Students were not asked to describe how they knew the purposes, nor were they asked how they could test to see whether their responses indicated an accurate perception. Their responses did indicate an understanding of the markings' purpose in comparison to the lesson's objectives in the case of camouflage ("Students will understand that a snail's shell markings serve as camouflage"), but did not meet the second part of the objective ("Students will understand that a snail's shell markings attract other snails"), and indeed, stated something far different from what the teacher intended. The teacher did not introduce the other half of his objective, nor confront the students about their response. It seemed a logical conclusion to state that snails could tell each other apart by the markings on the shells, considering fingerprints can be used to tell humans apart. The students were asked to find a relationship between the whorls on a snail and whorls on humans, and that is exactly what they did.

In Mr. Hinckley's culminating lesson about snails, his objectives were for students to create a display for the hall. This lesson objective was similar to an earlier lesson's objective to create a hall display by having students dip snails in paint and having the snails "paint" trails of different colors across construction paper. To create the hall display in the culminating lesson, students were asked to make a second drawing of a snail—how the snail really looked. Students were not asked to compare their second drawings with their original drawings, but were asked to mount both drawings on a piece of black paper. Again, during student drawing time, Mr. Hinckley sat at the front of the room looking at other papers. Students were not asked to look at the differences in the drawings, but turned in their mounted drawings when they were finished. There was no discussion about the different versions of the snail drawings. Though Mr. Hinckley talked about the importance of helping children know their understandings, by not helping students make accurate observations about the snails and draw inferences, he hindered their scientific understandings and making sense of their own ideas.

Ms. Duncan

Ms. Duncan, the third grade teacher, stated she listened to student theories, and wanted students to know their own ideas. Student ideas were a good way for the teacher to understand how to plan future lessons, and for students to know their own understandings.

T: I always wish they would listen and examine their own theories, but oftentimes I think that's a learned thing to do. And I find at this age group what the kids are mostly focusing on is what they're going to say when it's their turn. So I try to break them out of that a little bit, structuring, "look at the person who's presenting and ask questions about 'what did that kid say that's like what you found?'" It does require focus.

Her manner of assessing student ideas was developing into a way to know student ideas at the beginning of a unit in comparison to their ideas at the conclusion of the unit:

T: What I do is try to evaluate what the kids' conceptions were before we started the unit compared with growth during the end. Like draw a snail before the kids actually see one, and then compare it to a drawing or explanation that they might make after they've studied one. And this year I had them do little clay models of the snail, and they were remarkably accurate.

She was aware of her influence on what students learn and how their ideas developed, and realized that what she did would help them gain an accurate understanding of what she wanted them to learn.

T: Well, I want to be able to ask questions that will focus the kids' attention on things I'm hoping that they pick up, rather than just random sets of questions, and so I'm focusing on things like "Why do you think the snails' tentacles retract?" That kind of thing.

Mrs. Duncan required her students to make a drawing of a snail as they "really looked" prior to beginning the unit on snails, as did the previous two teachers. However, she first asked her students to make individual written lists of things they "knew" about snails. They were given about 15 minutes to do each portion of the lesson. While her lesson plan indicated she require them to draw the initial picture, added the written list to gain more understanding of what students understood about the behavior of snails, in addition to snail appearance.

Follow the listing of ideas and drawing of the snails, the students spent about 20 minutes exploring snails. The teacher circulated the room as they worked, asking probing questions to encourage students to think about what they were observing. For instance:

S: See, the eyes go in when they are touched.

T: What makes you think they are eyes?

The students were reconvened as a class group, and given definitions for observation and inference. This portion of the lesson was very didactic, with the teacher providing specific definition:

T: Observation is telling something like a reporter would. Telling exactly what you see, feel, taste, hear, or smell. Inference is explaining why you think something happened. For an inference you need to be careful, because you don't really know why something happened. You are trying to figure it out.

The teacher knew the students had no backgrounds understanding of the words "observation" and "inference" and provided direct instruction in this instance. Students were then asked to return to their desks, and make observations and inferences about their snails. Students seemed to do a very good job of this, and to have an accurate understanding of observations and inferences. (See Figure 2 for an example of student work on this problem.)

OBSERVATIONS	INFERENCES
When I touched Part 1 it went in.	1 I think it went in because it was scared.
When I touched Part 2 it was slimey.	2 I think it's slimey because It goes through puddles.
when it touched Part 3 it went in.	3 I think it went in because it was scared.
Shell She has a hard shell.	Shell It I think it as a hard Shell so it is harder to kill them.

Figure 2. Example of third grade observation and inference worksheet.

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When reconvened as a whole group, their responses were varied:

S_1: My observation is that it feels slimy. My inference is that when a snail is afraid it gets slimy.

S_2: My observation is when you touch the feeler the cord goes inside the head. I think it does it because the cord goes in to help it see.

During the second lesson, there were no specific objectives for finding out what students knew about snails. However, as the lesson proceeded it was evident that the teacher did provide opportunity for students to share their ideas. In this lesson students were required to measure their snails, and to then build accurate, life-size models of a snail. The teacher gave direct instruction for how to measure, using an overhead projection of a demonstration of measuring things of different lengths. She gave students a worksheet of what they were to measure, including the length and height of the snail, but then asked:

T: Is there anything else you think will be good to measure to help you build your snail model?

S_1: Antennas!

S_2: Shells.

T: Good—there are lots of things about a snail you might want to measure to make it an accurate model. What if I am measuring something that covers up the numbers of my ruler? What can I do to still be able to measure it? Does anyone have any ideas?

S_3: You could mark a line at the end of the ruler, and move the thing so you can see the number the mark is by.

Within the above discussion, students were allowed to provide suggestions for measuring, and for ways to solve problems they may encounter when measuring. The teacher encouraged them to think about going beyond the requirement of the worksheet, and about how to think of their own solutions when encountering difficulties.

Students spent about 45 minutes measuring their snails, and building snail models. Upon completion, each pair of students shared their snail models with the class, and peers were to comment on the accuracy of their models. It was interesting to note that the clay the students used to build their models was not snail-colored, so some comments peers made about the accuracy of the models was how they had tried to overcome the problem of the color of the clay.

The third lesson observed was not the culminating lesson of the unit. Ms. Duncan decided to carry on her students' investigation of the snails past the time of this study. Her plan for culminating the unit was to have students carry out an investigation of what snails

could climb over and crawl on. The third lesson observed showed the students thinking about things they had observed during their explorations with snails, and things they had learned about snails from sources other than observation, such as books. Students worked in groups of two on this assignment, and then shared their lists as a class group. Ms. Duncan wanted them to infer from their observations, and thus, asked probing questions to encourage the students to tell more.

T: Let's talk about what you observed. What did you find out?

S_1: Snails are slimy on the bottom.

T: Why do you think it is helpful for a snail to be slimy?

S_1: So a snail can glide along more easier.

T: What else did we observe?

S_2: Snails could move their eyes in different directions at the same time.

T: Why do you think it is a good idea for snails to be able to do that?

S_2: For protection against predators.

In some cases students became confused about the difference between knowledge gained from observation and knowledge gained from other sources. The teacher did not want the confusion to remain, and so pointed out the difficulty, as is shown in the example below:

S_3: I learned what when snails are eaten they are called 'escargot.'

T: But that is not something you learned by observing. That is something teacher told you. Your partner can help you think of something you learned by observation.

In some instances Ms. Duncan asked for students ideas to be shared, such as when she required students to list what they knew, and draw the pictures of the snail as they thought the snail really looked. In these instances she knew the students had background knowledge, and wanted to uncover that knowledge. In other instances, she knew students did not have background knowledge. For instance, when learning about observation and inference, she knew students had likely not heard the terms before, thus provided direct instruction in the vocabulary. To help students learn the difference, she allowed them direct exploration with snails, coming up with their own examples of observations and inference. Thus, she was allowing student ideas within the structure of her lesson. Her lesson objective was met by both didactic and inquiry components, based on what she deemed appropriate from student background knowledge.

Student perceptions of teacher practices

Students in all classrooms held positive attitudes toward science and the science teaching conducted by their respective teachers. Students supported the methods and practices used by the teachers. Students made only positive comments about their teachers and science. In the Kindergarten classroom, student interview responses indicated they believed their teacher wanted them to focus on correct procedures and on following directions:

S_1: We do that stuff that she wants us to do, and stuff.

I: Oh, that's nice. What does she like you to do when it's science?

S_1: Just wants us to do whatever she tells us to do.

S_2: Tells us what we do.

I: Okay. And what does she want you to do when it's time to learn science?

S_2: Clean up the table, and we have to wait 'til she calls our name.

I: What does your teacher do when she's teaching you about snails? How does she help you learn about them?

S_3: She tells us what to do. And we get to hold them too.

I: Oh, you do?

S_3: And be careful with them. You don't want to bang on em.

I: No. What would happen if you banged on them?

S_3: It would die.

I: That would be sad, huh? Cause they're nice. What does your teacher like you to do when it's time for science?

S_3: She tells us what to do.

One student recognized that the teacher brought in things for students to look at for science explorations. The student also recognized the teacher liked students to observe what was occurring, using tools such as a magnifying glass.

I: What does your teacher do help you learn science?

S_4: We don't do it any more, but she brought a beehive here with a whole bunch of bees.

I: Okay. And what does your teacher like for you to do when it's time for science?

S_4: She wants me to get a microglass (magnifying glass), and look really close at stuff.

Though there was still a perception of following procedures the teacher wanted, the second graders focused more on the questions their teacher asked them. They believed their teacher asked them certain questions in order to help them "figure stuff out" and "discover things."

I: What did your teacher do that helps you?

S_1: He explains it to us and he lets us try it out on our own. We made little snail houses and stuff and he just gave us two pieces of string and toilet paper tube to put holes through. So we had to put it together.

S_2: And he talks about the things.

I: What kinds of things does he say when he talks?

S_2: He asks us questions. Then we experiment to see what we can find out.

S_3: Um, he helps us discover things and we, um, he asks us a lot of questions.

They also noted that their teacher wanted them to be good listeners and follow the directions.

I: What does he like you to do when it's science time?

S_1: Just pay attention.

S_2: Sit down and listen.

S_3: Study and concentrate on what we're doing.

The third graders also focused on following their teacher's directions, mentioning "clearing their desks" as an important part of science.

S_1: Yes she likes us to do it right. She says, "Clean off your desk," and, yeah, she says, "Clean off your desk and have nothing on your desk except for a pencil."

S_2: She likes us to get our desks cleaned off and get ready to do it.

However, several of their comments showed a focus on how the teacher helped them think about experiments and "figure out things." Their responses indicated an awareness of the teacher's focus on helping them learn rather than telling them what they should know.

S_1: Well, at first she got the snails from a different school, and she got the sheets and all that stuff ready for us.

S_2: She helps us do stuff, and gives us ideas for figuring things out.

S_3: Um, well, hum, we do kind of science projects. Lots of them.

Student perceptions of the importance of their ideas

The kindergartners mentioned several things that indicated their awareness of the importance of their ideas in science. First, they mentioned how, by making certain statements, they could direct the conversation. They were aware that the teacher would allow their comments to influence class discussions. The comment below illustrates this nicely, by showing how one student realized he could direct the conversation by mentioning his own interests.

I: Do you ever get to talk about things you think about in science?

S: Yes. Like, if I say dinosaurs, then we get to talk about dinosaurs. Then, like, we can talk about how do dinosaurs get made, how do dinosaurs get their teeth fallen out, how do they get blood all over it. Because they eat other dinosaurs. Sometimes they just eat plants. But like, the t-rex and the philososaurous and the raptors, they just love meat and blood. Like sharks, they smell blood, they attack their prey. They're really hungry.

Second, they mentioned the teacher always holding "times for talking" during which students all discussed what they were learning in science. They described moving as a group to the front of the room for a whole group discussion.

I: Do you ever get to talk about things you think about in science?

S: Yeah. We are on the carpet and we would talk about it.

Third, the students mentioned the teacher "likes us to talk about things we think in science," and "likes us to know what we think."

I: Do you ever talk about things you think about when it's science with you teacher?

S_1: Uh hum. She likes you to know what you think.

I: Do you ever get to talk about what you think about science in your class?

S_2: Sometimes. She likes to know what we think about. About slugs and bees.

The second graders also believed their teacher valued their ideas and thoughts. They mentioned the teacher giving students ways of making records or recording and using their ideas. The movie discussed by the student below was a movie small groups made about snails.

I: Do you ever get to tell your teacher about ideas you have in science?

S_1: When we did the snails he had his calendar what we learned and we told him things we thought so he could put them on it.

S_2: On the movie we made, we had to watch the movie then we had to write on a piece of paper what we think we needed for the answers. He said, on the paper it said lets analyze our movie. So what we did is we watched the old movie and then we wrote stuff to make it better. Then we did the new movie.

Their responses indicated they recognized the teacher's questions as helping them think about what they were learning during these discussions.

I: How does the teacher know what you are thinking?

S_1: We are always having these big discussions about stuff. The teacher always asks us questions so he knows what we think.

I: So what kinds of things does he do to help you learn?

S_2: He talks to us a lot. He lets us try stuff, like outside.

They noted that the teacher was not telling them things, but helping them figure them out.

I: What did your teacher do that helps you learn about science?

S: Um, he helps us discover things and we, um, he asks us a lot of questions about what we're doing. And he lets us discover things.

I: How does he let you discover things?

S: He doesn't tell us the answer he just lets us discover it.

The third graders believed their teacher liked them to share ideas, and was genuinely interested in what they thought and why they thought certain things. Students mentioned that when they were observing snails their teacher would ask them questions, and would sometimes ask them to share their observations with the class.

I: What does your teacher do that helps you learn science?

S_1: Well, if we don't understand something she'll come over, and like, if we're reading something about science and we don't understand it, she'll just come over and explain what it means and stuff. She asks us questions about what we're doing. At the end we have to write it in a report.

I: So you write a report and are those things that you studied? Or things that you looked up? Or both kinds of things?

S_1: They're sort of both.

S_2: She likes to know what we think. Cause like, one time she asked us if we had any, like if we thought that if snails ever get sick or something like that

Students felt free to disagree with other students, but they could resolve differences in opinion by testing things again to see what the new results will be.

I: Do kids sometimes disagree with other kids?

S: Lots of times.

I: What do you have to do to decide what makes sense?

S: Well, you have to talk with your partner and see if it makes sense.

I: So when you talk to your partner, sometimes do you agree with what's happening? And sometimes you don't agree? What do you do when you agree?

S: Well, we write it down and then we look at it and we say, "That looks good. Yep."

I: What if you don't agree?

S: Then I write it down and my partner says, "No, that doesn't look good," and we go back and do it again. We do another test to see, to kind of decide.

Another way in which the third graders shared ideas was through presentations to their whole class about things they learned.

S: Yeah, um, like, if, usually at the end of everything, when we're done learning about planets and stuff, we have to write a lot of things down that we wrote. And then the people who chose to be in the group, they go up in the front of the room and they read some stuff off.

S_2: Cause we had snail facts, and teacher picked the sticks, and certain kid read them, and it was in cursive, and all of them were nice.

Though students were able to share ideas, that did not mean all ideas were addressed in instruction, or that students did not continue to have misconceptions about the content. Consider the following misconception a student expressed in an interview, of which the teacher was unaware. It is possible this student was confusing snail shells with hermit crab shells.

I: Let's bring your little snail over here a bit. Let's pretend there are two scientists. One scientist says that this soft body of the snail can come all the way out of this snail shell. All the way out and leave the shell behind. The other scientist says that the snail shell is stuck to the snail's body. How would these two scientists decide which one of them is right?

S: Just see what happens over a week or a year. Because the snail can come out of the shell. And it tries to find a new shell. I seen it happen. I seen the snail just walking, sliding along. And it's shell just fell off. And it was still slimin' along.

I: Still slimin' along. And the shell fell off. When the shell came off what would it do?

S: Find a bigger shell. Cause that shell is getting too small.

Discussion

The teachers who participated in this study believed students had their own ideas about snails, and endeavored to know those ideas. All teachers elicited student ideas about snails, prior to instruction, but in different ways. Methods for collecting student ideas grew increasingly complex with higher grade levels. The kindergarten teacher asked students to draw pictures of snails as children believed them to be. The second grade teacher asked students to vocally share what they knew about snails in a large group discussion, as well as making drawings of snails. The third grade teacher asked students to create individual written lists of what they already knew about snails in addition to drawing what they knew about snails. The increasing expectancy is likely due to the greater developmental levels of older children. Kindergartners would not be able to make individual written lists, though they would have been able to participate in a group discussion regarding their ideas about snails. There was also an increase in the amount of time given students to collect student ideas about snails by grade level. Kindergartners spent only about 15 minutes drawing their snails, whereas the second graders drew for 30 minutes. Third graders recorded written ideas for about 20 minutes before even beginning to make their drawings. The increase in time is appropriate due to increasing attention span of third graders in comparison to kindergarten children.

One point on which all teachers were similar is in having students observe actual snails, and then make new drawings based on their observations. In addition to making second drawings, the third grade teacher asked students to make accurate models of snails from clay. From these two representations of snails, one prior to student exploration with snails, and one following the exploration, one would think the teacher would have students make comparisons of the two versions. Having students compare the two versions would allow students to confront their original ideas about snails and realize the advantage of being able to observe the snails in making more accurate representations. However, only two teachers asked students to compare the two versions of the representations. The kindergarten teacher helped students note the differences between the two drawings her students made in a class discussion, while the third grade teacher had her students note the accuracy of their peers' models of snails. The second grade teacher did not have students note the difference between their representations of snails. It seems that though the teachers all recognized the need to know their students conceptions of snails, not all were successful at helping students know their own ideas, or to compare the growth of their ideas.

Knowing the importance of student ideas did not guarantee recognition of all ideas. One is reminded of the student in the third grade classroom who believed the snail's shell would come off and the snail would search for a new, larger shell. The teacher was unaware of the idea this child held. It would have been interesting to note, what, if anything, the teacher would have done had the idea been public.

The teachers used student ideas differently. The kindergarten teacher used students' ideas in each lesson, yet did not always allow students to draw their own

conclusion. She focused on students' expression of ideas, and she drew the conclusions for the students. She was very concerned that she not allow students to draw erroneous conclusions, and helped avoid this by focusing their attention toward certain ideas. The second grade teacher listened to student ideas in group discussions, yet did not address them in instruction through activities, nor did he help students draw conclusions or note similarities. He did not focus students on particular ideas. Indeed, he introduced an activity during which students may have focused on the wrong idea (the relationship between fingerprints and snail shell whorls) and did not help students to note an accurate conception. The third grade teacher used a combination of didactic and inductive strategies to help students build on their ideas. For ideas for which she knew students had background knowledge she encouraged them to share their ideas. For ideas she knew students had no, or limited, background knowledge, she chose to present the ideas, and then allowed children to explore the new ideas with their own understandings. She focused students on their ideas using class discussions, and small group discussions, during which she asked probing questions that directed students to the idea she wanted them to learn.

Regardless of the teachers' views and manners of addressing student ideas, all students enjoyed science and believed their teachers valued their ideas. Students in all grade levels noted a procedural focus in science, but also a focus on specific things teachers did to encourage learning in science. From the youngest kindergartners to the older third graders, students noted class discussions as a major focus in their classroom. Class discussions were places where children talked about their ideas, the results they had obtained from investigations, and where they listened to other children. Even kindergarten children recognized they could direct the discussion by statements they made.

Thus, the students' perceived their ideas were important to their teachers. They perceived their ideas could direct discussions, and indeed, this was the case. In the case of the third graders, their ideas directed the focus of the lesson. Student ideas and results obtained from explorations were always shared in the class discussions, and through small group presentations. Students indicated they learned much from their peers, particularly from the discussions and peer presentations.

The teachers participating in this study all believed student ideas were important to know, and the students perceived the importance placed on their ideas by their teachers. Student and teacher perspectives of the importance of student ideas were very similar. As in the case of the second grade teacher, teachers sometimes did not use student ideas to plan future lessons, but simply valuing student ideas and asking students to share their thoughts was perceived by the students. Students in these three classrooms recognized their ideas were important in the science classroom.

Implications

These results imply that if elementary teachers are aware of student ideas, and planned to address them in instruction, students may be more aware of their own ideas and the role they play in learning science. Students in these three classrooms recognized their ideas were important and valued in science, whether or not their ideas were addressed in future lessons. Students recognized their own influence in the classroom, particularly

during class discussions. Helping children focus on the importance of their own ideas and thoughts about science concepts could contribute to better conceptual understanding of science. Helping students improve in their conceptual understanding would be helping them to meet the *Standards* (NRC, 1996). Students will be more aware of their own conceptions, and how those conceptions may change with observations and explorations in which they engage in the classroom. Teachers who are aware of the importance of and elicit student ideas could help primary students become more reflective about their own ideas and understandings. The reflection could come as a simple comparison of ideas and understandings before and after instruction. Teachers who are explicit in sharing differences in student conceptions will help students be aware of their own growth in knowledge.

However, it is also the case that even if teachers intend to know student ideas and to use them in their teaching, they are not always successful in gaining accurate perceptions of student ideas. The third grade teacher in this study was not aware that one of her students believed a snail traded its shell for larger ones. The second grade teacher did not successfully teach to his objectives of the purpose of the shell, and may have actually left the students with a misconception about the shell's purpose. Another implication is that knowledge of the importance of student ideas is not sufficient to help teachers to help their students build accurate conceptions. Knowledge of student ideas does not guarantee they will be used as a starting point for building new ideas, nor that they will be used at all in instruction. A good beginning is for teachers to know the importance of recognizing student ideas. A necessary next step would be to help teachers understand what to do with children's ideas. Simply knowing the ideas is not enough to help teachers know how to address them in lessons. Teachers need to be encouraged to explore ways to scaffold students' thinking toward more accurate conceptions. Scaffolding student ideas goes beyond mere eliciting of ideas, but necessitates ways to address the ideas through discussion or activity.

Future research should focus on noting conditions during which teacher recognition of student ideas influence teaching practice. When, and under what conditions, do teachers decide to address student ideas in their teaching? How will they choose to respond to student ideas, and what will students gain from teacher actions? If students perceive the importance of their ideas in the classroom, how, or will, they perceive lessons planned to address their specific ideas? These questions warrant further research.

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Appendix

Interview Protocol for Primary Students (teaching perception questions validated against the CLES [Taylor et al, 1994] and STEBI [Enochs et al, 1990]). Students were interviewed individually or in pairs. Teachers helped select students for interview based on a range of high, medium, and low-achievement in science, and a balance of gender. Students were interviewed in a location away from other distractions. During the interview there was a container of snails nearby, plastic on which to place the snails for observation, and a magnifying glass available. Interviews were post-instruction.

Questions to provide student perceptions of teacher actions:

1. What does your teacher do that helps you learn science?
2. What does your teacher want you to do when it is time for science?

Questions to provide student perceptions of the importance of their ideas:

1. Do you have ideas about science that you talk about in class?
2. Do you ever tell your teacher about your ideas about science? When?

Questions to provide student perceptions of content:

1.Tell me something you know about the snail. How do you know that? What did you do to find out?
2. Look at the snail's shell. Why do you think it has that shape? What do you think the shell is for? How do you know?
3. What are these for (pointing at the feelers)? What does it use this top set for? How about the bottom set? How do you know? What did you do to find out?
4.How do snails move? How do you know? What did you do to find out?
5.What do snails eat? How do you know? What do they like to eat most? How do you know (if they don't know, as 'How could you find out?')?
6.Did you enjoy studying snails? Why did you study snails? How do scientists decide what to study?
7.What do you do when you observe something? If you wanted to know which things snails liked to move on best, how could you find out? How would you know if you were right?

Teacher Interview Protocol (Teaching questions validated against the CLES [Taylor et al, 1994] and STEBI [Enochs et al, 1990]). Teachers were interviewed individually. Teachers were interviewed in a location away from other distractions. Interviews were post-instruction.

1. How do you decide what to teach in science?
2. Describe a typical science lesson? How does a science lesson proceed in your classroom?
3. On what do you want your students to focus during your lessons?
4. What are your overall objectives for students to learn in science?
5. How do you plan what you are going to teach in science?
6. What affects your planning of science lessons? What considerations do you make when planning to teach science?
7. What do you consider important for students to learn in science? How do you assess student learning in science?
8. What do you want students to do during science lessons? How do you want them to behave? How do you want them to interact with other students? With you?
9. What do you want students to know about the nature and processes of science? How do you hope to teach this to students? How do you assess what they are gaining?